since the noble metal content of this is much higher than that of IrMn noted above, the MR degradation in annealing is much lower and therefore high MR ratio could be realized to enlarge ΔRs, whereby the output could be increased. In the spin valve film having an ultra-thin free layer which can hardly realize good thermal stability for MR, most preferred for the best thermal stability for MR is a combination of a subbing Cu layer with a spin filter effect and a layer of PtMn. In place of PtMn, also employable is PdMn or PdPtMn (noble metal content: 40 to 65 at.%).

From the viewpoint of thermal stability for MR, it is desirable that the subbing Cu layer has a thickness of at least 1 nanometer. This is because, if the thickness of the Cu layer is smaller than 1 nanometer, the thermal stability for MR will be poor. However, when the thickness of the NiFe layer is not smaller than 4 nanometers, the Cu layer may well be 0.5 nanometers thick for good thermal stability for MR.

The specific electric resistance of PtMn is large and is nearly the same as that of IrMn. Therefore, PtMn is favorable, as having little influence on the current magnetic field. For those reasons, the films (7-3) ad (7-4) are extremely favorable to practical applications.

However, one demerit of PtMn is that, since its critical thickness for producing a unidirectional anisotropic magnetic field is larger than the critical thickness of IrMn, it is

difficult to thin the PtMn film to 5 nanometers or so. Therefore, when PtMn is used, it is desirable that the thickness of its film falls between 5 nanometers and 30 nanometers, more preferably between 7 nanometers and 15 nanometers or so. The same idea as in (7-4) where the underlayer below the free layer has a two-layered structure could apply also to PtMn.

As variations of the embodiments (7-1) to (7-4), a noble metal element film could be laminated on the antiferromagnetic film. For example, a single-layered or laminated film of any of Cu, Ru, Pt, Au, Ag, Re, Rh, Pd and the like may be used. The variations could realize low Hin even when the spacer is thin. However, if the noble metal film is too thick, the current flow ratio will increase in the upper layers over the free layer. Therefore, the thickness of the single-layered or laminated film preferably falls between 0.5 nanometers and 3 nanometers or so.

As has been mentioned hereinabove with reference to Fig. 15, the bias point control in the spin valve films of this Example is much better than that in those of Comparative Cases 1 to 4, and the films of this Example could ensure the best bias points.

As also mentioned with reference to Fig. 16, the spin valve films of this Example produce higher MR ratio than that to be produced by the films of Comparative Cases 1 to 4 essentially bellow 45 nanometer Tesla free layer.

Example 2: Top SFSV (with simple CoFe free layer)

5 nanometer Ta/x nm Cu/2 nm CoFe/2 nm Cu/2.5 nm CoFe/0.9 nm Ru/2 nm CoFe/7 nm IrMn/5 nanometer Ta (8-1)

5 nanometer Ta/x nm Cu/2 nm CoFe/2 nm Cu/2.5 nm CoFe/0.9 nm Ru/2 nm CoFe/10 nm PtMn/5 nanometer Ta (8-2)

In this Example 2, used is a simple free layer of a single-layer CoFe, being different from the laminate free layer of NiFe/Co or NiFe/CoFe as in Example 1. In Fig. 1, the structure of this Example 1 has a single-layer CoFe as the free layer 102 and a single-layer Cu as the high-conductivity layer 101.

As already mentioned ultra-thin free layers below 4.5 nanometer Tesla in NiFe face various difficulties. The single-layer CoFe free layer is advantageous in that the soft magnetic characteristics control is relatively easy even though the thickness of the layer is extremely small. A third additive element of B, Cu, Al, Rh, Pd, Ag, Ir, Au, Pt, Ru, Re, Os or the like could be added to CoFe, if desired. However, if pure Co is used in place of such CoFe alloys, soft magnetic characteristics characteristics could not be realized. CoFe preferably falls between $Co_{85}Fe_{15}$ (at.%) and $Co_{96}Fe_{4}$ (at.%). As will be mentioned hereunder, the defined composition range for CoFe is based on the magnetostriction control.

From the view point of soft magnetic characteristics, the CoFe free layer is preferably oriented in fcc(111). From